

## **CHAPTER 2. GEOLOGY AND MORPHOMETRY OF THE PARKER RIVER-PLUM ISLAND SOUND ESTUARY**

### **2.1. Overview**

The original DMF monograph reported data on the morphometry and geology of the Plum Island Sound region. Some of this has been updated by the Massachusetts Geographic Information Systems (MassGIS) unit and by more recent soil surveys of Essex County. New information on postglacial movements of the barrier beach is based on the work of Duncan Fitzgerald and his students at Boston University and information on intertidal bedforms is based on the work of Joan Daboll from her work at the University of Massachusetts.

### **2.2. Methods**

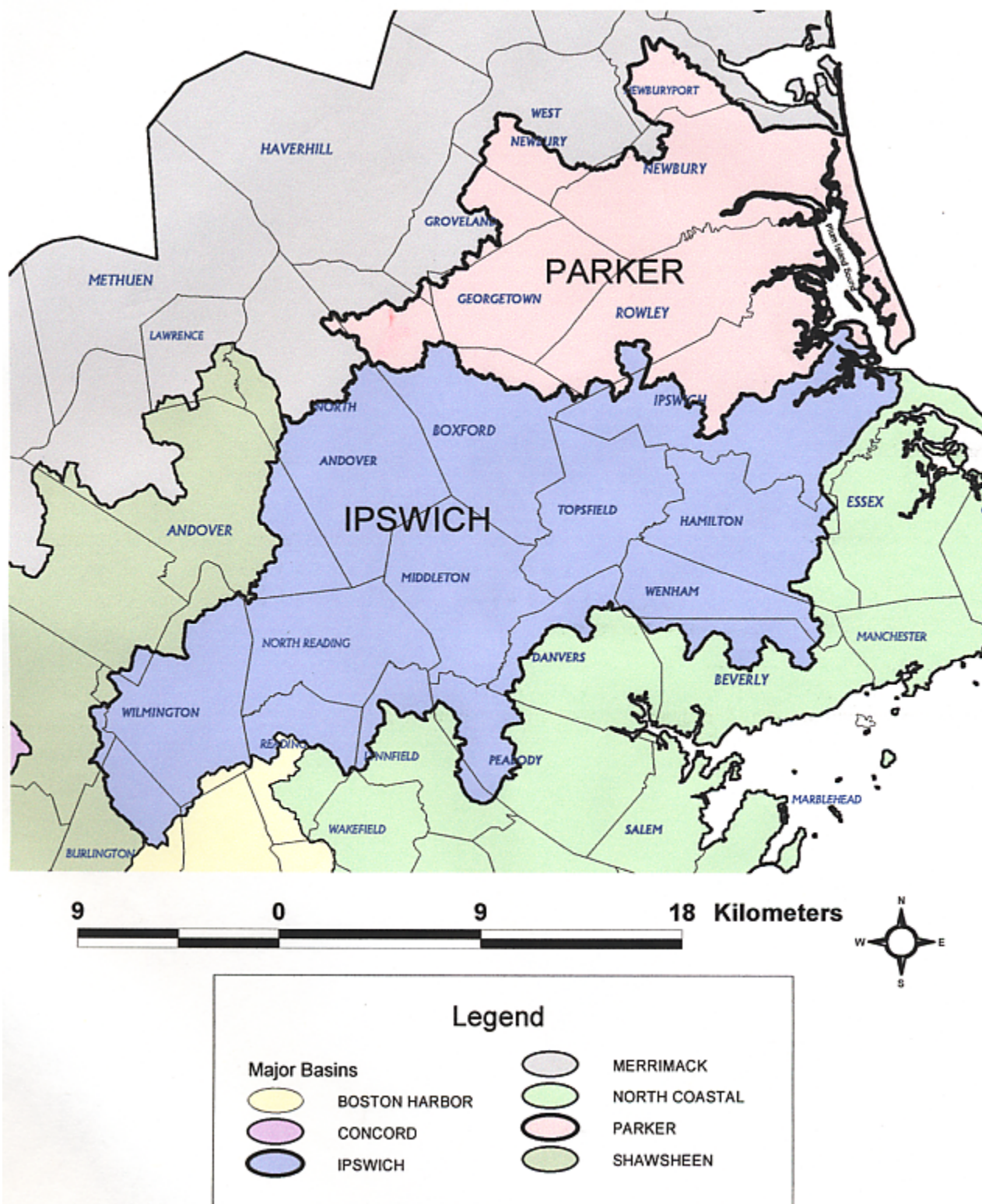
Coast and Geodetic Survey Chart #213 with a scale of 1:20,000 was used for all morphometric measurements in Jerome et al. (1968). Linear measurements were obtained with the use of a graduated straight-edge and a map rotometer. All area measurements were computed with a dot grid overlay. Updated measurements were taken from the watershed, subbasin, and 1:5000 data layers available from MassGIS.

### **2.3. Geography and Morphometry**

The Parker River/ Plum Island Sound estuary is located in the towns of Newbury, Rowley and Ipswich. This estuary is formed primarily by the Plum Island Sound, the Parker, Plum Island, Rowley, Eagle Hill, and Ipswich rivers and (Fig. 2.1). Major tributaries to the Parker River include Mill and Little Rivers, Newbury. The Parker and Rowley Rivers drain a watershed of about 212 km<sup>2</sup> (Fig. 2.1). The Ipswich River watershed covers 401 km<sup>2</sup>, and is by far the largest watershed draining into the Sound. The Ipswich River enters the Sound close to its mouth between Little Neck and Steep Hill.

The estuary contains a vast network of tidal creeks, large and small, which meander through approximately 3500 hectares of salt marsh. These vastly increase the amount of shoreline. The maximum length of the study area is 13.2 km (actual stream length, approximately 22.5 km), but the length of shoreline within the estuary is 262 km. The total surface area of the estuary is 1810 hectares (MHW) or approximately one-half the acreage of the surrounding salt marsh.

Fig. 2.1. Watersheds of the Parker River/ Plum Island Sound estuary, including the Ipswich River.



Plum Island Sound is a relatively shallow estuary as indicated by its depth contours (Table 2.1). The average depth within the study area varies from 3 m (MHW) to 1.6 m (MLW) depending on the tide. The percentage change in water volume between high and low tide is 68.6 percent.

Table 2.1. Area of Submerged Contours for the Parker River-Plum Island Sound Estuary, 1965.

Mean Low Water

Depth (feet)	1965 Area	1965 Percentage of Total
0-6	2,106	78.2
6-12	336	12.5
Over 12	250	9.3

Mean High Water (feet)

Depth (feet)	1965 Area	1965 Percentage of Total
Intertidal Area	1,778	39.8
0-6	2,106	47.1
6-12	336	7.5
Over 12	250	5.6

Table 2.2. A summary of the significant morphometric measurements of the area (modified from Jerome et al. 1968; MassGIS):

<i>Maximum Length:</i>	13.18 km
<i>Maximum Effective Length:</i>	8.50 km (mean high water, MHW) 3.31 km (mean low water, MLW)
<i>Maximum Width:</i>	3.00 km (MHW) 1.80 km (MLW)
<i>Maximum Effective Width:</i>	3.00 km (MHW) 1.11 km (MLW)
<i>Mean Width:</i>	1.37 km (MHW) 0.84 km (MLW)
<i>Maximum Depth:</i>	15.24 m (MHW) 12.50 m (MLW)
<i>Mean Depth:</i>	3.0 m (MHW) 1.6 m (MLW)
<i>Mean Depth-Maximum Depth Relation:</i>	0.20 (MHW) 0.13 (MLW)
<i>Maximum Depth-Surface Area Relation:</i>	0.004 (MHW) 0.004 (MLW)
<i>Total Surface Area:</i>	1,810 hectares (MHW) 1,090 hectares (MLW)
<i>Length of Shoreline:</i>	261.6 km (MHW) 219.5 km (MLW)
<i>Shore Development:</i>	17.32 (MHW) 18.72 (MLW)
<i>Volume:</i>	54,782,973.7 cu. meters (MHW) 17178852.3 cu. meters (MLW)
<i>Salt Marsh Area:</i>	3,405 hectares (33.9 sq. km)
<i>Mean Tidal Amplitude:</i>	2.6 m (Ipswich River Entrance)

## **2.4. Geological Background**

Bedrock in the drainage basins that surround Plum Island Sound, “is primarily metamorphosed sedimentary, igneous, and volcanic rock, and unaltered igneous rocks. Most of the bedrock is overlain by unconsolidated materials that were deposited during and after the last advance of the glaciers...” (Jerome et al., 1968 and references cited within).

### **2.41. Bedrock**

"There are two types of bedrock in the Parker River estuary (Clapp, 1921 as cited in Jerome et al., 1968). Above the Route I-A bridge the estuary is underlain by the Lynn Volcanic Complex, which is chiefly metamorphosed volcanic rocks containing abundant quartz and light-colored feldspar. The area downstream from the bridge is underlain by the Dedham Granodiorite, which is a coarse-grained, metamorphosed igneous rock containing abundant quartz and white and pink feldspar. It commonly has white feldspar crystals up to 5 centimeters long.

"The Rowley River estuary is underlain by Salem Gabbro-Diorite. This medium-grained, metamorphosed igneous rock contains white to light-gray feldspar and abundant dark ferromagnesian minerals."

### **2.42. Surficial deposits**

#### *2.421. Glacial and postglacial history*

The last glacial episode ended about 10,000 years ago in the region and left a strong impact on the landscape of the region. Glacial till overlies bedrock throughout much of the area. Thick deposits of till on top of bedrock occur on North Ridge and Plover Hill in Great Neck. Drumlins, low “hogback” hills of glacial debris with one steep side and the remainder sloping gradually, are prominent features. Examples include Castle Hill, Old Town Hill, and Sandy Point.

During the time of the last glaciation, the sea level in the region was about 400 feet lower than at present. The sea level rose as melting glaciers released vast amounts of water. Silt and clay were deposited in lowlands newly inundated by the rising sea. “As the glaciers disappeared, removal of their weight on the earth's crust caused rebound (or uplift) of the land which raised some of the marine silts and clays above present day sea level. The fine-grained deposits of the lowlands bordering the Parker and Rowley Rivers were formed in this manner, and were later covered, in places, by tidal marsh deposits (Jerome et al., 1968). The tidal marshes started to develop approximately 6000 years ago in conjunction with the formation of the Plum Island barrier Beach (McIntire and Morgan, 1962).

"Sea level stopped rising about 3000 years ago (McIntire and Morgan, 1962; Kaye and Barghoorn, 1964 cited in Jerome et al. 1968). Uplift of the land near this coastal section of Massachusetts ceased between about 7500 and 6000 years ago (McIntire and Morgan, 1962; Kaye and Barghoorn, 1964). From that time a slight downward warping of the crust of the earth caused the land to subside again." At present, sea level is rising in relation to the land.

#### *2.422. Soil Types*

A variety of soil types occur within the Plum Island /Parker River Estuary (Table 2.3 and USDA, 1981). The soil types in a given locale have a direct bearing on where septic systems should be located. Soils that are well to moderately well drained with a year round low water table are best suited for a traditional septic tank with a leaching field.

#### *2.423. Intertidal bedforms*

In general, large bedforms are abundant in the easterly sandy areas and their morphology is a result of current patterns at the mouth of the estuary. The orientation of these bedforms change depending upon the channel depths; in the main channels they tend to be ebb-oriented, whereas in the smaller creeks they are flood oriented. The shape and pattern of the internal bedforms vary with type of sediments present. The distribution of shellfish and other biota are dictated by the grain size of sediments. In sandy regions the medium grain sands tend to shift more often than the fine grain sands due to varying current velocities, with low velocity conditions most apt to move smaller sediments, therefore larger populations of shellfish are often found in the fine grain sand conditions. Grain size tends to decrease further up the estuary. Within the main channels the coarsest sediment is found on the highest elevations, but this tendency is reversed in the smaller tributaries (DaBoll, 1969).

The consequences of the erosion and deposition of sediments in the sound have a direct bearing on shellfish harvesting. The development of the highly productive Roaring Bull clam flat in Ipswich is a testament to the shifting sediments in the mouth of the estuary. Boothroyd and Hubbard (1975) determined that bedform type is dictated by the maximum flood and ebb tide velocities, the difference of maximum flood and ebb tide velocities, and the time span above a given velocity.

Table 2.3. Soil Types in the Plum Island Sound Estuary. Unpublished data from the Parker River Watershed Team, Massachusetts Executive Office of Environmental Affairs (EOEA, 1996).

Location	USDA Abbreviation	Type	Properties
Lower Section of the Parker River	IW	Ipswich and Westbrook Mucky Peats	Poorly Drained, Inundated Daily
Lower Section of the Parker River	AgA	Agawam Fine, Sandy Loam	Well Drained, Moderate to Rapid Permeability
Lower Section of the Parker River	BxC	Buxton, Rock Outcrop	Well Drained, Bedrock Exposures
Lower Section of the Parker River	RoD	Rock Outcrop, Charlton-Hollis Complex	Found on Slopes of 15 to 35 % slope, Shallow
Lower Section of the Parker River	MA	Maybid Silt Loam	Deep, Poorly Drained, Slow Permeability
Lower Section of the Parker River	CcC	Canton, Extremely Fine Sandy Loam	Moderately Rapid Permeability
Lower Section of the Little River	IW	Ipswich and Westbrook Mucky Peats	Poorly Drained, Inundated Daily
Lower Section of the Little River	RnC	Rock Outcrop, Buxton	Exposed Bedrock with moderately well drained soils, Moderately slow permeability
Lower Section of the Little River	RnD	Buxton	Soils that occur on 15-25 % slopes, exposed bedrock, moderately well drained soils, soil permeability, seasonal high water table
Lower Section of the Little River	BuB	Buxton Silt Loam	Soils that occur on 3-8 % slopes, moderately well drained, high water table
Lower Section of the Mill River	IW	Ipswich and Westbrook Mucky Peats	Poorly Drained, Inundated Daily

### 2.43. Hydrology

The complex flood-tidal delta system that makes up the Plum Island Sound Estuary is comprised of a main river, the Parker, and a series of many tributaries of the Parker, the largest include: the Mill River, the Little River, and the Rowley River. The large amount of salt marshes and fresh water wetlands present throughout the watershed acts to minimize the impacts of coastal flooding.

Hydrographic data show the estuary to be predominantly horizontally and vertically mixed (Daboll, 1969). Salinity stratification is slightly horizontal, especially during the ebb period in the upper estuary. The maximum salinity level difference was

4%. Daboll also noted that ebb currents were stronger than flood currents in the main channel, but flood currents were stronger in the smaller tidal creeks and mudflats.

Precipitation in the Parker River Basin according to the rain gage located in Newburyport averages 108 cm per year from 1913 to 1995. On average rainfall is 10.3 cm in the wettest month, November, and 2.8 cm in the driest month, August. Evapotranspiration is about 44% of the rainfall with the rest draining into the ocean as runoff (EOEA, 1996).

Approximately one-third of the runoff from the Parker River Basin is measured at the stream gauge in Byfield. The flow duration curve for the Parker River at the gauging station indicates that there is a moderate amount of natural storage in the upper regions of the watershed. Data from the stream gauge indicate that flows averaging at least 10 cfs occurred 70% of the days of record (EOEA, 1996).

#### 2.44. Origin of Plum Island

"Plum Island began as a mainland beach about 6000-7000 years ago. As the land subsided and sea level rose, the shoreline should have migrated rapidly westward. However, an abundant supply of sand from the Merrimack River and sand plains to the north resulted in enlargement of the beach. Vertical growth of the beach kept pace with sea level rise and land subsidence, and the beach became an offshore bar. A salt-water marsh between the offshore bar and the mainland developed contemporaneously with the bar. Onshore winds blew beach sand above the storm high tide line and formed dunes which migrated landward covering some of the adjacent marsh deposits. Wind and wave action resulted in a gradual shifting of the shoreline to the west. Longshore currents carrying sand southward along the coast and depositing this sand along Plum Island shore extended the island southward until it was connected to the small hill of glacial till at the southern tip of the island" (McIntire and Morgan, 1962).